

SCIENCE FOR GLASS PRODUCTION

UDC 666.1.053.562(047).001.6

DEVELOPMENT OF FLOAT PROCESS IN SHEET GLASS PRODUCTION

V. I. Kondrashov,¹ E. V. Fainberg,¹ and V. S. Bezlyudnaya¹Translated from *Steklo i Keramika*, No. 6, pp. 11 – 14, June, 2000.

Three independent methods for float glass production developed by Pilkington (England), PPG Industries (USA), and the Saratov Institute of Glass (Russia) are described. Fundamental differences between these methods are considered. Phases of the development of two-stage glass-molding technology at the Saratov Institute are described.

In the 1960s various countries started to develop sheet glass production technologies based on the new molding method using a tank with molten metal for fire polishing of glass surface. The use of this method led to substantial improvement of glass quality parameters and increased production efficiency with a simultaneous decrease in glass production expenses.

This research and development was based on an original concept expressed in 1902 and 1905 in the patents of American inventors H. Hill and H. Hitchcock.

According to this concept, plate and sheet glass shaped as a continuous belt of any required thickness is carried out by outpouring glass melt from the glass-melting furnace to the adjacent tank which contains a melted material whose specific weight is higher than the specific weight of the glass. As a consequence, the glass melt spreads and in the form of a continuous band keeps floating above the melted metal surface; then it is removed from the melt surface and sent to the annealing furnace (Fig. 1).

The British company Pilkington in 1952 started research in the field of production of a continuous glass band and after 7 years of experimental, prototype, and industrial studies and substantial investments obtained a high-quality product. In January 1959, Pilkington made public its new technology, which led to rapid growth in the production of high-quality glass.

Research and development of domestic machines for float glass production started in the USSR in 1959. In the same year the Saratov branch of the State Institute of Glass was founded, whose purpose was to develop an original float glass technology.

After a series of research, experimental, and prototype studies in laboratories and on continuous production lines, a

two-stage molding method was developed in 1969 (USSR Inventor's Certif. Nos. 230393 and 556593, U.S. patent No. 4081260), and an experimental float glass production line (ÉPKS-4000) was put into service manufacturing the first commercial products.

At the same time, research in this field was carried out in Ukraine at the Avtosteklo factory (Konstantinovka), where three float glass production lines were later put into service. The first two lines (TPS-1500 and TPS-3000 with band width 1500 and 3000 mm, respectively) made it possible to produce polished glass 6 – 7 mm thick. The third was a specialized line for production of glass 6 to 20 mm thick designed by the research and design bureau of the GIS Institute using Inventor's Certificates from the Avtosteklo Works.

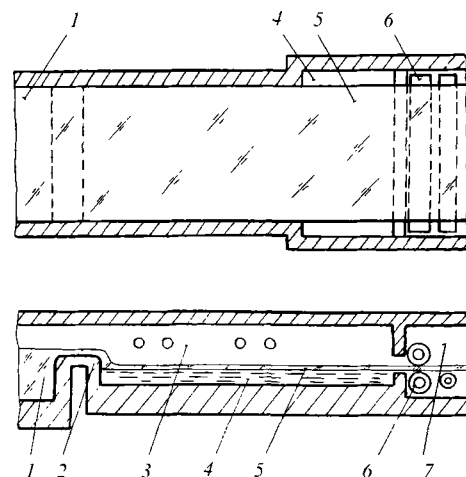


Fig. 1. Method for glass molding on metal melt invented by H. Hill and H. Hitchcock (U.S.): 1) liquid glass melt; 2) discharge threshold; 3) heating chamber (tank); 4) metal melt; 5) glass band; 6) pulling rollers; 7) annealing furnace.

¹ Saratov Institute of Glass, Saratov, Russia.

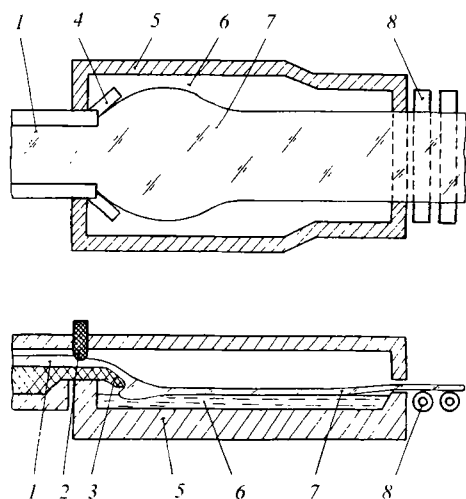


Fig. 2. Method for float glass production developed by Pilkington: 1) liquid glass melt; 2) weighing discharge gate; 3) discharge chute; 4) restrictors; 5) melt tank; 6) tin melt; 7) glass band; 8) slag chamber receiving shafts.

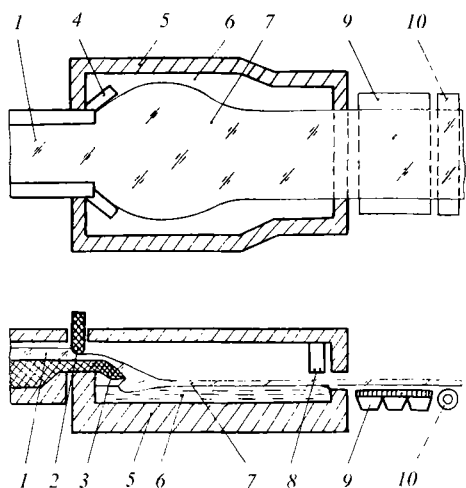


Fig. 3. Two-stage method for float glass production developed by Saratov Institute of Glass: 1) liquid glass melt; 2) weighing discharge gate; 3) discharge chute; 4) restrictors; 5) melt tank; 6) tin melt; 7) glass band; 8) induction coil; 9) gas-air cushion; 10) annealing furnace receiving shafts.

In 1974, PPG Industries (U.S.) patented its own method for float glass production (U.S. patent No. 3843346), which differs from the methods of Pilkington and the Saratov Institute. The former method was implemented on several float lines and is recognized as original.

Thus, three conceptually different methods are known in float glass production.

The Pilkington technology consists of transferring glass melt from the melting furnace to the melt tank using free discharge along a narrow chute which is located at a certain distance from the tin surface. The molded glass band is transferred from the melt tank to the first shaft of the annealing

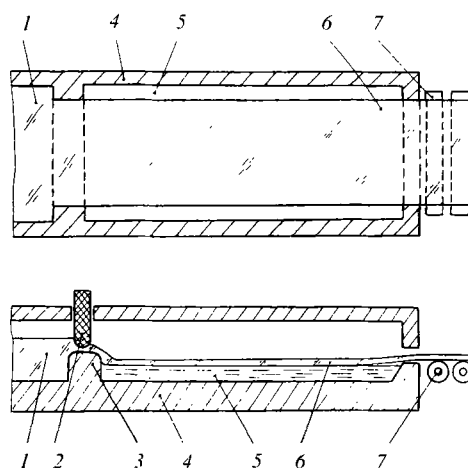


Fig. 4. Method for float glass production developed by PPG Industries: 1) liquid glass melt; 2) weighing discharge gate; 3) discharge threshold; 4) melt tank; 5) tin melt; 6) glass band; 7) slag chamber receiving shafts.

furnace (slag chamber) having a temperature of 600–615°C and is lifted above the exit threshold (where the band is bent), whereas the tin level in the tank is 8–10 mm lower than the threshold level (Fig. 2).

According to the two-stage technology developed by the Saratov Institute, the glass band without being bent leaves the melt tank and arrives at the gas-air support (cushion) at a temperature above 650°C (Fig. 3). The tin level in the tank in this case is 2–3 mm higher than the threshold level, which is accomplished through using electromagnetic induction coils also developed at the Institute (USSR Inventor's Certif. Nos. 248917 and 392674). The second stage of the glass formation occurs on the gas-air cushion where the band is cooled. At the same time, the geometrical shape of the band is fixed, after which the band is transmitted to the receiving shafts of the annealing furnace.

The advantage of the two-phase molding method consists in the possibility of transferring glass band to the annealing furnace receiving shafts at a lower temperature (570–580°C), which is 20–35°C lower than the temperature used in the Pilkington technology. As for the tin oxide reduction process, since the tin temperature in the exit part of the tank is about 50°C higher (which amounts to about 650°C), the process of tin reduction is more intense, which improves the quality of the undersurface of the glass band.

The float glass technology developed by PPG Industries differs from the methods developed by Pilkington and the Saratov Institute of Glass in having a special device for discharging glass melt from the glass-melting furnace into the melt tank. According to this technology, the glass melt is transported in the form of a horizontal layer from the furnace onto the surface of the metal contained inside the tank at the same level as the transported glass layer (Fig. 4). This method makes it possible to produce a glass band without its spreading in the form of a pool, i.e., without disturbing the

laminar state of the glass layer fed to the tank, which ensures the production of glass (both thick and thin) with good optical parameters.

The Saratov Institute of glass in the course of developing its original technology in 1964 – 1966 performed extensive research in the field of float glass production. At the same time, the Institute developed and constructed laboratory stands and continuous production lines which produced a glass band from 150 to 600 mm thick. Four prototype lines were constructed by the end of 1966, which served for studying the processes of glass formation, interaction of glass with tin, and the protective atmosphere. Glass melt in these and subsequent prototypes was discharged via a chute which was located at a certain distance from tin.

In 1965 – 1966 it was suggested that the gas-air cushion (Fig. 5) be used as the second stage of formation (cooling) before transporting the glass band to the annealing furnace shafts.

In the beginning, the tin level inside the melt tank was maintained by pouring tin over the threshold and subsequent pumping of tin into the tank melt.

The developed technological parameters and design solutions served as the basis for the design of the experimental line ÉPKS-4000 intended for production of glass band up to 1.2 m wide (net). This production line was multiply reconstructed and used for studying the technology and machinery for two-stage glass molding; in particular, a system of inductors was designed for preserving the elevated tin level, and the gas-air cushion was designed in two variants (direct-flow type and circulating type).

The first melting tank was 15 m long, and at present it is increased up to 30 m. This production line produces glass of various thickness up to 1600 – 1800 mm thick. The line ÉPKS-4000 was reconstructed in 1978 – 1981: the head part of the tank was widened from 2400 to 4300 mm, and the narrow part increased from 1800 to 3400 mm width, a circulation gas-air cushion was installed, and barriers were inserted in the tin melt to control the tin flow. The line efficiency increased up to 100 – 110 tons/day with an annual output of 2 – 3 million m² of glass.

Today, several technologies have been implemented on this line and a wide range of products is currently being produced:

- bulk-tinted float glass from 2 to 12 mm thick having bronze, gray, greenish-sky-blue, pink, and amber colors with different degrees of saturation and preset heat-shielding properties;
- “Metelitsa” and “Metelitsa Blues” architectural float glass with decorated surface in the form of randomly alternating glossy and dull areas; “Rhythm Glass” with undulated surface having various wave heights and various intervals between the waves, and electrochemically treated glass with increased chemical resistance.

In the period from 1969 to 1973, i.e., before the first industrial line LDF-5000 was started at the Saratov Technical

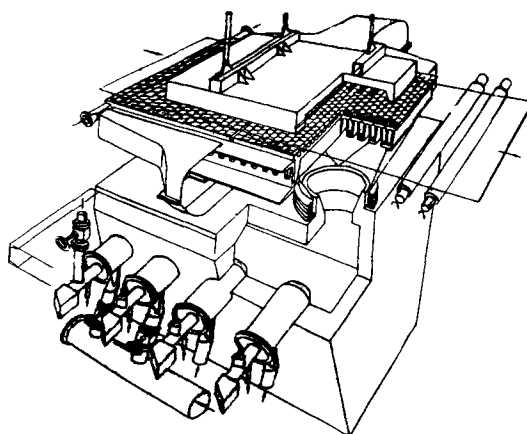


Fig. 5. Gas-air cushion.

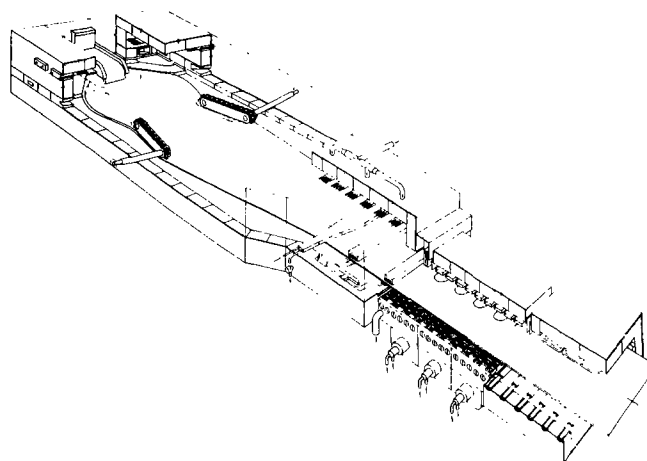


Fig. 6. Two-stage molding line.

Glass Works, certain technical solutions were tested on the line ÉPKS-4000 which later were used on all production lines based on the two-stage molding technology (Fig. 6).

Line ÉPKS-4000 was essentially the first industrial mini-line in the world practice, and the Saratov Institute of Glass developed on its basis a series of mini-lines with the width of the glass band ranging from 1300 mm (Lisichanskii Proletarii Works) to 2600 mm (design in Alma-Ata) and output from 150 to 250 tons/day.

Altogether 8 lines based on two-stage molding technology were designed and built, and six of them currently operate. Two of these lines (LDF-5000 at Saratov Technical Glass Works and II-LDF-5000 at Salavatsteklo production company) with glass band width up to 3200 mm were designed by the GIS design bureau based on a technical task prepared by the Saratov Institute of Glass, and the rest are mini-lines fully designed by the Saratov Institute including the melting tank, the annealing furnace, and the equipment for finishing operations.

The first line (LDF-5000) was started at the Saratov Works in November 1973, and the second one (II-LDF-5000) was put into operation in 1975 at Salavatsteklo Production Company.

The Saratov Institute of Glass participated in the installation and start-up of all LDF lines. Listed below are the main stages of this work:

- LDF-5000 at Saratov Works: start-up of the line, implementation of the technology for production of glasses 5 – 6 mm thick using the direct drawing method, adjustment of the gas-air cushion and inductors;

- LDF-2 at Saratov Works: implementation of the technology for thin glass production (4 – 5 mm thick) using caterpillar thinning machines, implementation of the production technology for Metelitsa glass; adjustment of recirculating gas-air cushion;

- LDF-3,4 at Saratov Works: adjustment of the technology for thin glass (3 – 5 mm) production using caterpillar thinning machines;

- LDF-5,6 at Saratov Works: adjustment of the technology for production of glass 3 mm thick using tin flow disectors;

- II-LDF-5000 at Salavatsteklo Company: complete start-up work and implementation of the technology for producing

glass 3 – 6 mm thick, adjustment of the induction system and the gas-air cushion parameters.

- LDF at Lisichansk Proletarii Works: complete installation and start-up of glass production for various glass thickness; adjustment of the induction system and the gas-air cushion.

In this way the two-stage molding method was implemented both on large capacity and mini-production lines.

At present the only line using this technology are the II-LDF-5000 lines at Salavatsteklo company, which achieves the best quality among domestically produced glass.

In addition to LDF lines, the Saratov Institute participated in the preparation of technological forms and records for design of float glass lines and their operation adjustment at the Salavat, Lisichansk, Kuvasai, Tokmak, and Gomel glass works.

The Saratov Institute of Glass has more than 30 years of experience in production of sheet glass on top of melted metal, which is the foundation for a new generation of float lines intended to satisfy the increasing demand of Russia and CIS countries with respect to high-quality clear architectural and specialized glass with coating ensuring the required functional properties.